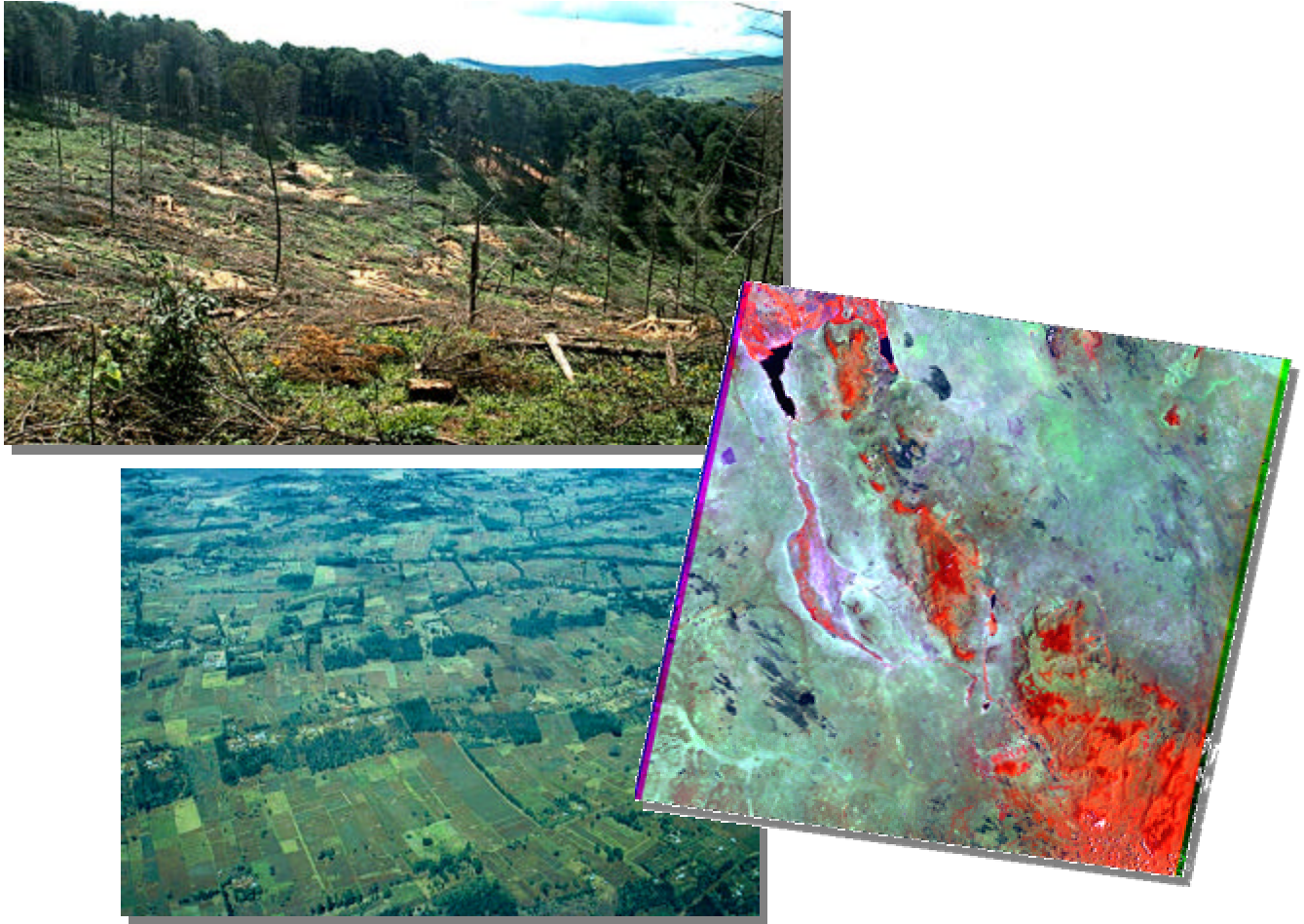


Monitoring for Sustainable Forests and Biodiversity in the Eastern Arc Mountains of Kenya and Tanzania



Submitted by the USDA Forest Service, International Programs

Final Report to USAID- March 2003

Final Report to USAID- Monitoring for Sustainable Forests and Biodiversity in the Eastern Arc Mountains of Kenya and Tanzania

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I. Eastern Arc Mountain Project Summary

The primary objective of this project was to develop a program of forest health monitoring utilizing a combination of remote sensing, permanent plots and aerial and ground survey techniques. Key project results provide an early warning system of stresses on the forest watershed through the use of specific indicators for sustainable forests. These results will enable land managers, planners, policy makers, interested communities and individuals with the status and trend information needed for making decisions on natural resource management issues and forest health assessment in east Africa.

The project was funded by USDA Forest Service and USAID, with USDA Forest Service providing technical support to help build local capacity in the forest health monitoring and remote sensing techniques of plot and imagery data in order to demonstrate the current status and trend in forest health. Utilizing USDA Forest Service expertise in remote sensing techniques and forest health protection, the agency provided support to in-country partners to continue monitoring and provided analysis of the EAM forest condition.

The following report provides an overview of the project's development, and describes activities and major accomplishments of the USDA Forest Service and partner organizations. Additional information can be found at: <http://www.easternarc.org>

II. Overview

The USDA Forest Service has been involved in East African forest health activities since 1994, when a formal agreement led to the creation of the Forest Health Center in Nairobi. A conference held in 1997 in Morogoro, Tanzania gathered over 200 people with intersecting interests in the Eastern Arc, and concluded that this unique ecosystem was undergoing an accelerated rate of destruction. It was concluded that an urgent need exists to monitor the problem if changes were to be made to reverse or slow the process. In September 1999, a second formal agreement was developed between Forest Service and Faculty of Forestry and Nature Conservation, Sokoine University of Agriculture.

The Eastern Arc Mountains are a unique chain of isolated mountains (440,000 ha) in Kenya and Tanzania that are directly influenced by the climatic effects of the Indian Ocean. Because of the great age of the mountains, and the relatively stable climatic conditions, the forests have existed for over 20 million years. These mountains are recognized as globally important 'hot spots' for forest biodiversity and are major national, regional and local sources of hydropower, water, and forest products. The age of the forests and their isolation from western African forest areas has led to an accumulation of endemic taxa. There are more than 2000 plant species in the Eastern Arc Mountains, of which 25% are endemic. Out of the 276 tree species, 50 are endemic.

Pressure on the Eastern Arc Mountains is coming from both human related causes, and, possibly from the indirect influences of damaging forest health agents such as insects, tree pathogens and animals. There are serious conflicts between the use of the ecosystem by the local people to meet their requirements for income and food production, and the sustainability of the forest resource with its unique biodiversity of flora and fauna. The montane forests have suffered extensive forest loss and forest fragmentation due to human disturbance and fire especially in the West and Eastern Usambara, Uluguru, North and South Pare Mountains.

The EAM forest health monitoring project assisted in gathering data, since little documentation exists for assessing the health of the forests. Additionally, little work is being done to identify the agents causing the changes, evaluate their relative importance, or to suggest ways to mitigate their impact. To solve these problems, reliable information must be available to determine the status and trend of the forest conditions to assist in planning and identifying the areas where changes are most needed.

III. Forest Health Monitoring in EAM - Highlights

The initial objectives of the project were to: 1) demonstrate that through new and existing forest health monitoring technology and techniques current trends in forest condition of EAM can be determined, 2) increase local practitioners knowledge in the use of forest health and monitoring technology through workshop and trainings, 3) assist in developing and improving regional institutions and agencies' abilities to conduct forest health monitoring and 4) design and implement an information technology system in order to improve communications between project cooperators. Based on the initial project activities, the following points describe project highlights:

- USDA FS technical support assembled 126 Landsat Path/Row scenes covering Kenya, Tanzania, and several surrounding countries. Images covering the EAM study areas were analyzed to show vegetation cover classes and land use change such as fragmentation and deforestation trends. The data was transferred to the Regional Center for Mapping of Resources for Development (RCMRD) in Kenya and the University of Dar Es Salaam in Tanzania for future monitoring and assessment activities.
- Forty-four forest health monitoring plots were established in the Eastern Arc Mountain area to determine and assess the long-term trends in forest health conditions. Local partner organization representatives including nine Kenyans and six Tanzanians, were trained during the plot monitoring and were certified to continue training others. In-country organizations were provided with the necessary tools continue monitoring the forest health plots and analyze data into useful information.
- Establishment of a web-site. <http://www.easternarc.org>, by the University of Georgia, demonstrates the capability and use of information technology systems, allows for improved communication between project coordinators, and disseminates information to government agencies, regional institutions, and NGOs and local communities.
- Strengthened coordination and cooperation between government agencies, regional institutions, NGOs and local communities. Information obtained will be used to improve land use patterns to increase food production, provide alternative income opportunities and reduce the impact of damaging forest agents.

USDA Forest Service's primary partners in the project include: Moi University, Forest Department and National Museums of Kenya, Sokoine University of Agriculture in Tanzania, University of Georgia and West Chester University. Local projects were supported by the United Nations Cross-Border Biodiversity Project, East African Wildlife Society, USAID with Tuskegee University, and World Wildlife Fund.

IV. EAM 2000- 2002 Project Activities

USDA Forest Service has been engaged in a number of activities, including the establishment of permanent forest plots, using remote sensing and special aerial and ground survey techniques, and the training of local individuals in the use of forest health monitoring information. These activities were considered fundamental if the region hopes to maintain long-term data gathering. Through a series of workshops, information exchanges, technical on-site trainings and the establishment of an information technology system, USDA FS provided information and knowledge for the region to begin assessing and outlining remedial actions. This section highlights the objectives and results of those activities.

A. Stakeholder Workshop on Remote Sensing for the Determination of Forest Cover Change, December 5-6, 2000, ICRAF, Nairobi, Kenya

This workshop brought together 19 participants from 14 major institutions, organizations, and programs using remote sensing and geospatial technologies operationally in Kenya and Tanzania. The participating organizations have used remote sensing and geospatial technologies primarily to conduct land cover mapping and land cover change analysis to help communities promote sustainable use of forest resources, protect watersheds, mitigate threats from rapid population expansion, and reduce biodiversity losses. Participants included the Kenya Forest Department, Kenya Wildlife Service, Moi University, Sokoine University of Agriculture, United Nations Food and Agriculture Organization, United Nations Global Environmental Facility, Cross Border Biodiversity project, Regional Centre for Mapping of Resources for Development, the Kenya Museum of Natural History, International Centre for Research in Agroforestry, National Environmental Management Council-TZ, University of Georgia, and USDA Forest Service.

Workshop Objectives

The overall goal of the workshop was to promote an understanding of institutional priorities and interests, provide clarity on threats and conservation opportunities in the region, and build consensus on strategic conservation actions, including a framework for potential collaborations and partnerships in the use of remote sensing and geospatial technologies.

The specific objectives of the remote sensing workshop consist of the following:

- inform participants on the Eastern Arc Mountain project
- gain a broader perspective of the remote sensing and geospatial activities of organizations and institutions of East Africa
- identify information requirements among workshop participants

- Provide opportunities for collaboration, leveraging of resources, and data sharing to meet information requirements, and to
- decide next steps and actions

Results

The workshop concluded that although satellite imagery is available, additional analysis is necessary for the remaining areas. There was consensus among all institutions on the need to facilitate improved communication and coordination, and make the information and projects derived from remote sensing more readily available. Strategic actions were proposed to address future land cover classification and forest cover change detection. These included discussions to increase collaboration among Eastern Arc Mountain Project cooperators with the Regional Centre for Mapping and Resources for Development and the FAO Africover Project.

B. Forest Health Monitoring in EAM

Establishment of Forest Health Monitoring Plots

Over the course of the EAM project, forest health conditions were described on the ground by establishing a series of permanent plots that were examined periodically by forestry specialists from the university and/or government sectors in Kenya and Tanzania. Information on the status and trend of the ecosystem's health were determined by measuring several indicators such as growth, tree condition, and damage indicators <http://willow.ncfes.umn.edu/fhm/fact/damage.htm>, ecosystem disturbance and others. Scientists working in the Eastern Arc Mountains had the opportunity to include additional indicators of ecosystem health on the monitoring plots. An off-plot survey component provided aerial surveys for tree mortality, defoliation, and dieback as well as ground survey for specific disturbances.

Final Field Training on Forest Health Monitoring, Voi, Kenya, June 17-21 2002

The final field training on Forest Health Monitoring is the second main objective of the EAM project with the goal of training partners on the ground in the use of forest health monitoring technology. Training allowed partners to acquire information on any forest ecosystem where continuous information is needed for planning or intervention where forest health problems are detected. This workshop was funded in part by USDA Forest Service, USAID, Sokoine University of Agriculture, UNDP/GEF-East African Cross Borders Biodiversity Project, East African Wild Life Society and the Commission for Natural Resources, Zanzibar.

The Forest Health Monitoring program was conducted in the Eastern Arc Mountains, coastal forests and Zanzibar's Jozani Forest. Since 2000, forty-four Forest Health and Monitoring plots have been established in the EAM mountains of Kenya and Tanzania.

In 2001 the program was expanded to include training of 15 East African cooperators, nine Kenyans and six Tanzanians professionals, in field procedures as well as establishment of additional plots in the Eastern Arcs, Zanzibar and coastal forests. The goal of this workshop was to provide East African partners the necessary tools and skills to continue the program. The workshop included presentation strategies and techniques in data analysis and data management. Also included were reviews of field techniques in data analysis and data management.

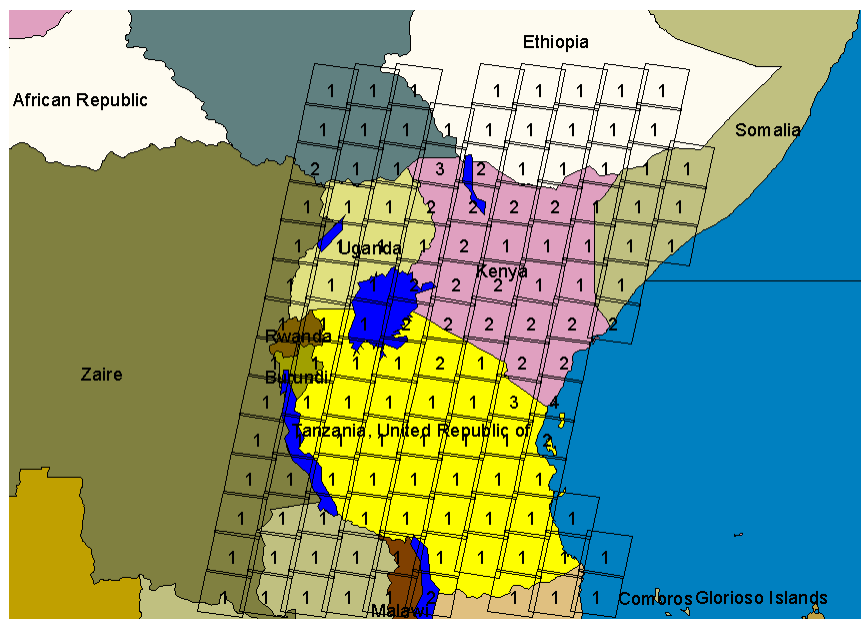
Results of the Forest Health Monitoring workshop

At the end of the workshop each country group devised workplans to continue the project, assigning reporting, data management, and field duties, as well as strategies for continued support. Following the week of training, certified East African crews installed permanent Forest Health plots. 17 plots were established in the Taita Hills (5 plots installed in 2000, 12 in 2001), 18 total in East Usambara (3 established in 2000, 15 in 2001), and 3 total in the Ulugurus (2 in 2000, and 1 in 2001), 3 in a coastal forest and 3 in Zanzibar.

C. Monitoring Changes in Forest Condition, Land Fragmentation, and Conversion

Objective

The aim of monitoring change in forest condition, land fragmentation, and conversion was to obtain remote sensing data of the EAM in order to analyze data to class by vegetation cover and conduct change detection analysis. The satellite imagery study areas are located in the Taita Hills, Usumbara Mountains, Pare Mountains, and the Uluguru Mountains.



The satellite imagery determines current location of forest resources, determines forest resource change over time (since the 1980s), and provides medium resolution image based geo-referenced map products, and is a source for satisfying ground sampling.

Catalog of Landsat TM Imagery acquired by the Eastern Arc Mountains project

The figure above illustrates the area covered by 126 Landsat Path/Row scenes acquired by the Eastern Arc Mountains Project. Each scene covers approximately 185 X 170 kilometers, represented by the rectangular polygons shown on the map of east Africa in the figure. The number within each rectangle (path/row) indicates the number of images acquired for that particular path and row. Images covering the Eastern Arc Mountains study areas were analyzed to show vegetation cover classes and to conduct land cover change analysis.

Landsat Thematic Mapper imagery was used to map land use changes in specific study areas in the EAM for vegetation assessment and change analysis. Preliminary analysis was conducted in the Taita Hills area, then carried out over the EAM chain- from the North and South Pare mountains to Uluguru, East and West Usambara, and Uzun gwa area in southern Tanzania. Vegetation classes were identified, followed by categorizing of non-forest and forest class changes based on data from 1987. This classification data provided change analysis scenes comparing past and current forest health condition of specific EAM areas.

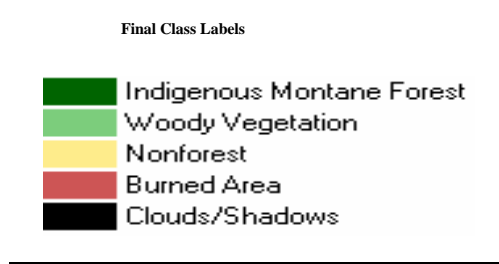
Taita Hills Change Detection Analysis

The following maps and slides provide an example and overview of monitoring changes in forest condition, land fragmentation and conversion by using remotes sensing to assess forest change.

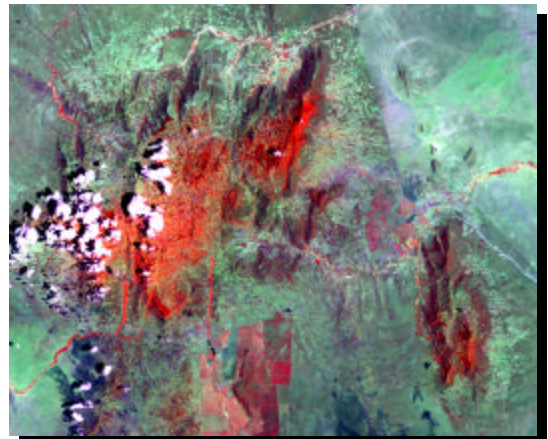
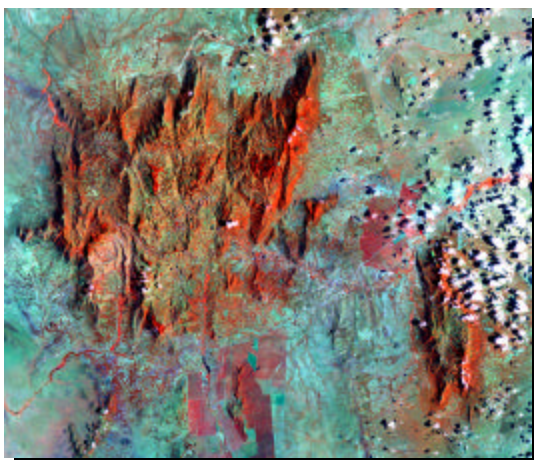
Figure 1- Taita Hills- satellite imagery



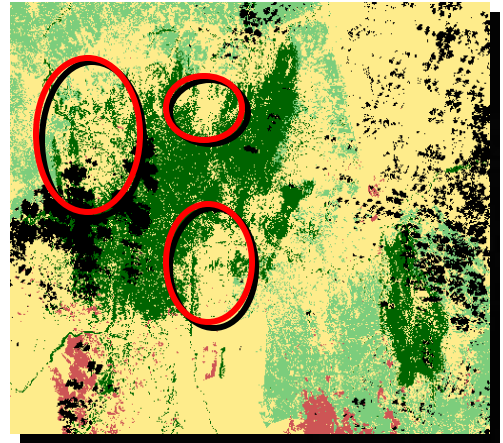
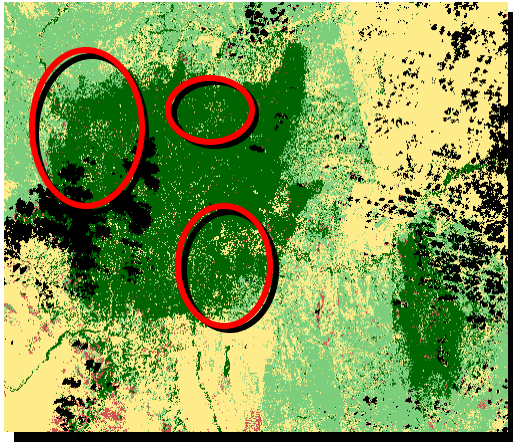
Figure 2 -Vegetation classification



1987 Landsat Images of the Taita Hills 1999

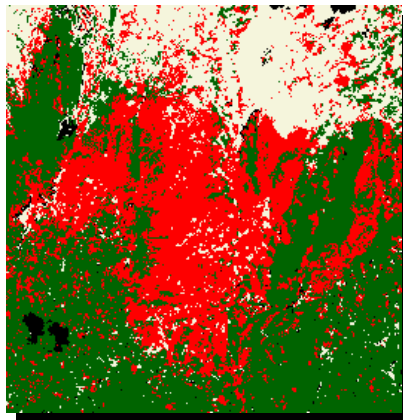


1987 Changes in areas are highlighted in red 1999



Change 1987- 1999

Based on this image classification it appears that there is much less montane forest in 1999 as compared to 1987.



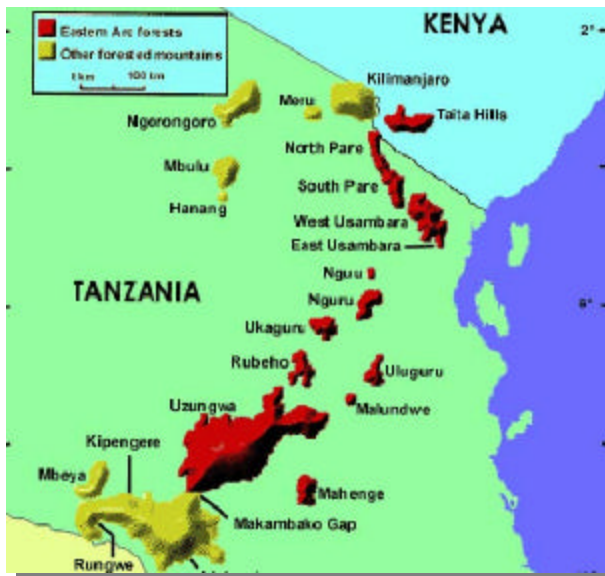
Future recommendations for better change detection analysis include: acquiring change detection images near the same annual calendar date and acquiring one set of data for both the rainy and dry seasons, continue to encourage active participation with local people familiar with the study areas as their knowledge provides insight on current and historical conditions.

D. Transfer of Remote Sensing Data and Imagery: In-Country Organizations House and Distribute Satellite Imagery

USDA FS technical support assembled 126 Landsat Path/Row scenes of East Africa covering Kenya, Tanzania with coverage including Uganda, Rwanda, and parts of other surrounding countries, that will help develop institutional capabilities for remote sensing in East African institutions. Images covering the EAM study areas were analyzed to show vegetation cover classes and to conduct land cover change analysis. USFS team member chose two in-country recipients of this data to be in charge of imagery distribution. These organizations, Regional Centre for Mapping of Resources for Development (RCMRD) and the University of Dar es Salaam in Tanzania are both equipped to house and reproduce the imagery as needed. The USFS team, with each organization, formulated and signed agreements in March 2002, outlining the terms for other stakeholders and interested parties to access the imagery. The imagery will be available to others at no extra cost other than reproduction costs.

Included in the imagery analysis is an aerial Survey of Ulugurus. This survey detected and evaluated Forest Health condition using aerial sketchmapping techniques and to validate analysis of remote sensing data. In the Ulugurus and East Usambaras remote sensing data was gathered to analyze data in order to class vegetation cover and conduct change detection analysis.

E. Web-Site Development and Maintenance



One objective of the EAM project is to improve communication between and among project cooperators and others by providing information and coordination for institutions and organizations working in the forested systems of the EAM region. A web-site, www.easternarc.org, has been established by the University of Georgia to provide information on activities of the project. This web-site includes a message board to allow investigators and cooperating institutions to interactively communicate with each other. Information such as proposals, work

plans, progress reports, trip reports, and news is posted on this web-site and are available to government agencies, regional institutions, NGOs, and local communities.

V. EAM Project Partners

Eastern Arc Forest Health Project
East Usambara Conservation Area Management Programme
Udzungwa Mountains Forest Management and Biodiversity Conservation
Uluguru Mountains Biodiversity Conservation Project
Tanzania Forest Conservation Group
East African Wildlife Society
University of Georgia
USDA Forest Service
USAID
Kenya Forest Department
Moi University
Sokoine University
Tuskegee University
Kenya Forest Research Institute
National Museum of Kenya
Taita Hills Biodiversity Project
West Chester University